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(71) Applicant
Rolls-Royce Limited (United Kingdom),
65 Buckingham Gate, London SW1E 6AT

(72) Inventors
John Edwin Doughty
Clive Norman Bunyan
Simon Peter Anker

(74) Agent and/or Address for Service
M A Gunn,
Rolls-Royce Limited, Patents Department, PO Box 31, Moor Lane, Derby DE2 8BJ

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(54) Anti-icing of gas turbine engine air intakes

(57) A turboshaft gas turbine engine 10 has an annular air intake 11 having a number of radially extending stator vanes 20 located around a reduction gearbox 17. A number of heat pipes 22 extend through the vanes 20 to interconnect the interior of the reduction gearbox 17 with a heat sink 28 situated adjacent the upstream lip 23 of the intake 11. Heat from the hot oil mist within the gearbox is thus conducted to the heat sink 28 and serves to heat up the intake lip 23 to prevent the formation of ice thereon, while at the same time the oil mist is cooled.

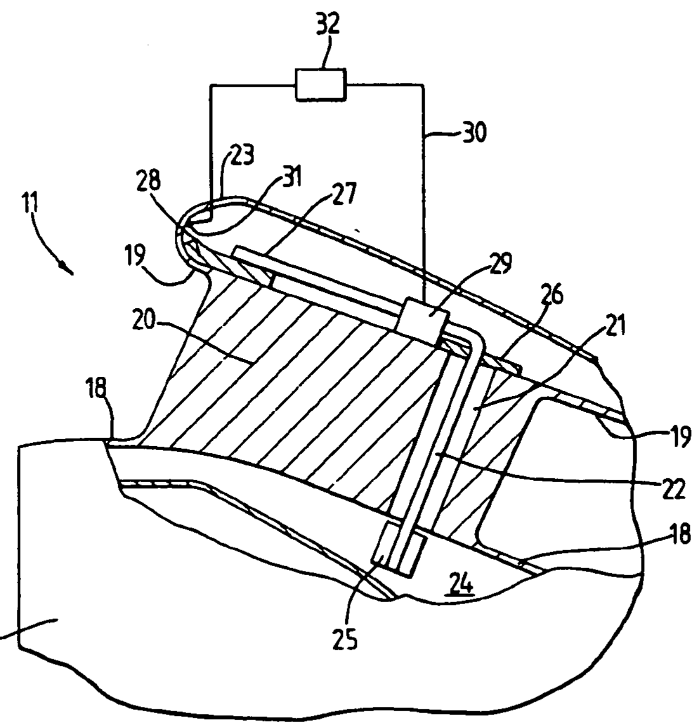

Fig.2.

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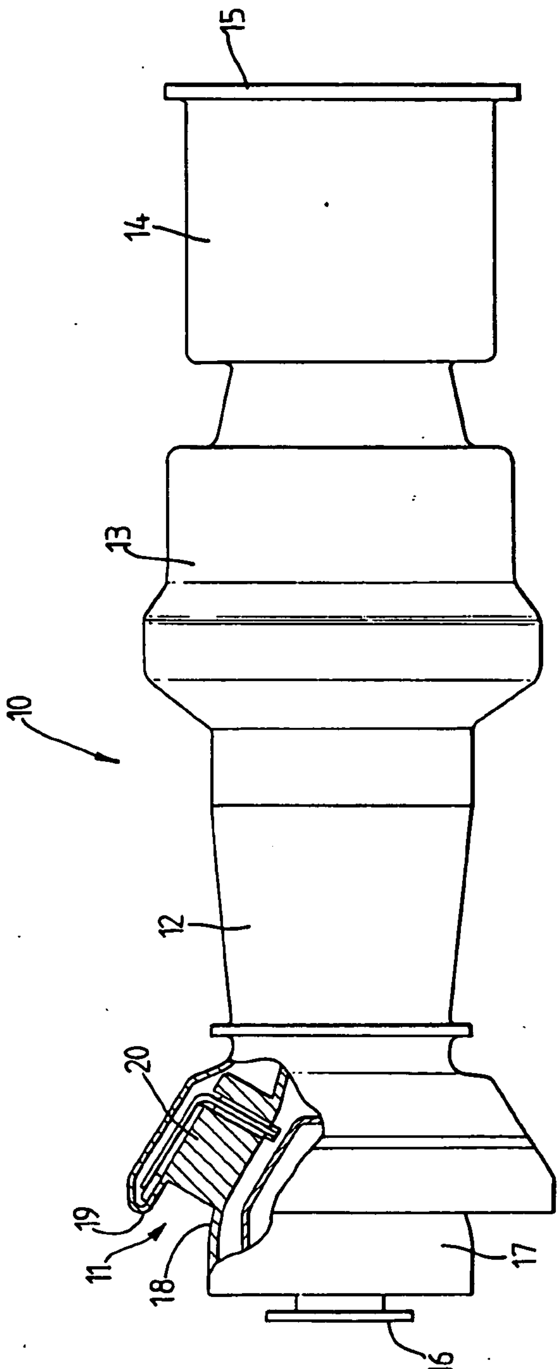

Fig.1.

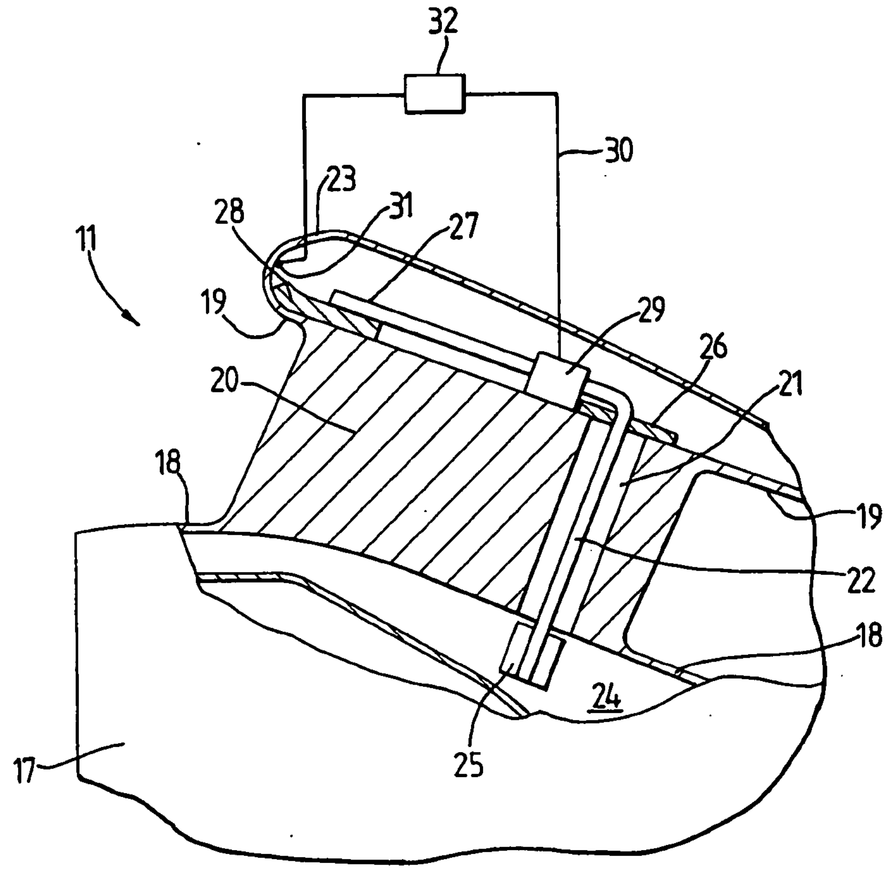

Fig. 2.

SPECIFICATION

Anti-icing of gas turbine engine air intakes

This invention relates to the anti-icing of gas turbine engine air intakes.

Certain portions of gas turbine engine air intakes are prone to the build-up of ice on their operative surfaces. This is extremely undesirable in view of the detrimental effect which it has upon engine power and safety. Means are usually provided to prevent such icing and these conventionally take the form of electrical heating elements embedded in the appropriate portions of the intake surface or alternatively small ducts carrying warm air which has been bled from a hot section of the engine. Both of these solutions, although effective in preventing the build-up of ice unfortunately have a detrimental effect upon the efficiency, and hence performance, of the engine.

It is an object of the present invention to provide a gas turbine engine having an air intake provided with anti-icing means which are effective in the prevention of ice deformation thereon but have a less detrimental effect upon engine efficiency than is the case with conventional anti-icing systems which rely upon intake heating.

According to the present invention, a gas turbine engine having an air intake is provided with at least one heat pipe which interconnects that portion or portions of said air intake which is or are, in operation, prone to the formation of ice thereon, with a portion of the lubrication system of said engine, said lubrication system portion having an operational temperature which is sufficiently high to heat up said at least one heat pipe to such an extent that the heat which it conducts to said air intake portion or portions prevents the formation of ice thereon.

The invention will now be described, by way of example, with reference to the accompanying drawings in which:

Figure 1 is a partially sectioned side view of a gas turbine engine in accordance with the present invention.

Figure 2 is an enlarged view of the sectioned portion of the gas turbine engine shown in Fig. 1.

With reference to Fig. 1, a turboshaft gas turbine engine generally indicated at 10 comprises, in gas flow series, an air intake 11, a compressor section 12, combustion equipment 13, a turbine section 14 and an exhaust gas outlet 15. The turbine section 14 is made up of two portions, one of which drives a power output flange 16 at the upstream end of the engine 10 *via* a reduction gearbox 17, also positioned at the upstream end of the engine 10.

The gas turbine engine 10 operates in the conventional manner in that air drawn in through the air intake 11 is compressed in the compressor section 12 before being mixed with fuel and the mixture combusted in the combustion equipment 13. The resultant exhaust gases expand through the turbine section 14 and are exhausted to atmosphere through the exhaust gas outlet 15.

The air intake 11 is of generally flared configuration in order to accommodate the reduction gearbox 17. It has coaxial radially inner and outer circumferential walls 18 and 19 respectively which serve to define its annular form. The walls 18 and 19 are interconnected by a plurality of radially extending stator vanes 20, one of which can be seen in the drawing.

Each of the vanes 20 has a radially extending passage 21 therein which, as can be seen in Fig. 2, contains a heat pipe 22 which is of conventional construction. Each heat pipe 22 is of generally L-shaped configuration with one arm of the L located within the passage 21 and passing through an enclosure plate 26 provided on the radially outer extent of the passage 21. The other arm extends in a generally upstream direction to terminate adjacent the upstream lip 23 of the radially outer wall 19 of the intake 11. The portion of the heat pipe 22 which is located within the passage 21 projects beyond the radially inner extent of the vane 20 to terminate in an enclosed space 24. The enclosed space 24 is part of the reduction gearbox 17 which, during the operation of the engine 10, contains a mist of the oil which is directed to the gearbox 17 for lubrication purposes.

The oil mist within the chamber 24 is hot and thereby serves to heat up that portion of the heat pipe 22 which projects into the space 24. Heat transfer fins 25 on the heat pipe 22 serve to assist in an effective heat exchange between the oil mist and the heat pipe 22.

The heat transfer medium which is contained within the heat pipe 22 is selected such that it vapourises at the normal operating temperature of the oil mist within the space 24. The vapourised heat transfer medium travels along the heat pipe 22 until it reaches the cooler regions thereof whereupon it condenses and its latent heat of vapourisation heats up those cooler regions. The condensed heat transfer medium is then capillary pumped back to the higher temperature portions of the heat pipe 22 by a suitable capillary pumping medium on the internal surface of the heat pipe 22, whereupon the cycle is repeated. Thus the heat pipe 22 serves to conduct heat from the oil mist within the space 24 along the whole of its length.

The end 27 of the portion of the heat pipe 22 which terminates adjacent the upstream lip 23 of the radially outer intake wall 19 abuts a heat sink 28. The heat sink 28 which may also be a heat pipe is in the form of a ring and it is abutted by all of the heat pipes 22

within the stator vanes 20. Thus the heat pipes 22 serve to transfer heat from the oil mist within the space 24 to the heat sink 28 which in turn heats up the upstream lip 23 of the radially outer intake wall 19. It will be appreciated that the heat sink 28 need not be in the form of a continuous ring but could be in the form of a series of segments, each of which is in communication with a heat pipe 22.

The heating of the upstream lip 23 by the heat pipes 22 serves to prevent the build up of ice on the lip 23 surface. It also serves to cool the oil mist within the space 24. This brings the additional benefit that the oil cooler which would normally be necessary to provide cooling of the oil within the engine 10 may either be dispensed with or made smaller than would normally be the case with a conventional engine. Consequently the cost, weight and power loss drawbacks which are associated with conventional gas turbine engine oil coolers are either reduced or, in certain circumstances, dispensed with altogether.

It may be found that in certain circumstances, the heating of the upstream lip 23 by the heat pipes 22 is unnecessary because the temperature of the air which is drawn in through the air intake 11 is high enough to prevent ice formation on the air intake 11. In these circumstances, the continued heating of the intake lip 23 may be detrimental to the efficiency of the engine 10 in view of the heating effect which it has upon air drawn in through the air intake 11. In order to provide for such a situation, a valve 29 is located in each heat pipe 22 which is adapted when actuated to restrict or prevent the free passage of vapour within its associated heat pipe 22. The valve 29 is connected by a line 30, which is shown diagrammatically in Fig. 2, with a temperature sensor 31 located on the upstream lip 23 of the radially outer intake wall *via* a control unit 32. The arrangement is such that if the temperature of the upstream lip 23 rises above a predetermined level, the control unit 32 causes the valve 29 to be actuated so as to restrict or prevent the free passage of vapour within the heat pipe 22. This has the effect of reducing the thermal conductivity of the heat pipe 22, thereby allowing the heat sink 28, and hence the upstream lip 23, to cool down. When the temperature of the upstream lip 23 falls to a level at which there is a danger of ice formation thereon, the control unit 32 causes the valve 29 to be actuated so as to permit the free passage of vapour within the heat pipe 22, thereby causing it to heat up the heat sink 28, and hence the upstream lip 23.

Although the present invention has been described with reference to a heat pipe which interconnects a portion of the reduction gearbox 17 of a turboshaft gas turbine engine 10 with with the upstream lip 23 of its air intake 11, alternative configurations are contemplated within the scope of the present invention. Thus, for instance, the heat pipe 22 could be configured so as to terminate in a different region of the lubrication system of the engine 10 if the engine 10 is not of the turboshaft type. Moreover, although in the described embodiment, the heat pipe 22 terminates adjacent the upstream lip 23 of the air intake 11, it could be configured so as to terminate adjacent other regions of the air intake 11 if those regions are prone to the formation of ice thereon.

CLAIMS

1. A gas turbine engine having an air intake provided with at least one heat pipe which interconnects that portion or portions of said air intake which is or are, in operation, prone to the formation of ice thereon, with a portion of the lubrication system of said engine, said lubrication system portion having an operational temperature which is sufficiently high to heat up said at least one heat pipe to such an extent that the heat which it conducts to said air intake portion or portions prevents the formation of ice thereon.

2. A gas turbine engine as claimed in claim 1 wherein said gas turbine engine is a turboshaft gas turbine engine having a reduction gearbox which is situated adjacent said air intake, said portion of the lubrication system of said engine being constituted by a portion of said gearbox which contains lubricant from the lubrication system of said engine.

3. A gas turbine engine as claimed in claim 2 wherein said air intake comprises coaxial radially inner and outer circumferential walls which define an annular air passage, said radially inner and outer circumferential walls being interconnected by a plurality of radially extending stator vanes, at least one of said vanes containing a portion of one of said heat pipes.

4. A gas turbine engine as claimed in any one preceding claim wherein said portion or portions which is or are, in operation, prone to the formation of ice thereon is or are situated adjacent at least one heat sink, said at least one heat pipe interconnecting said heat sink with said portion of said lubrication system.

5. A gas turbine engine as claimed in claim 4 wherein said at least one heat sink is in the form of a ring which is situated adjacent a portion of the radially outer wall of said air intake.

6. A gas turbine engine as claimed in any one preceding claim wherein said heat pipe is provided with means adapted to regulate the thermal conductivity thereof.

7. A gas turbine engine as claimed in claim 6 wherein said thermal conductivity regulating means comprises a valve member

which varies the rate at which vapour may travel through said heat pipe.

8. A gas turbine engine as claimed in claim 7 wherein said valve member is interconnected with temperature measuring means positioned adjacent said intake portion or portions which are prone to the formation of ice thereon *via* control means so adapted that said heat pipe only heats up said heat sink when the temperature of said heat sink falls to such a level that there is a danger of ice formation on the portion of said air intake which is adjacent thereto.

9. A gas turbine engine substantially as hereinbefore described with reference to and as shown in the accompanying drawings.

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